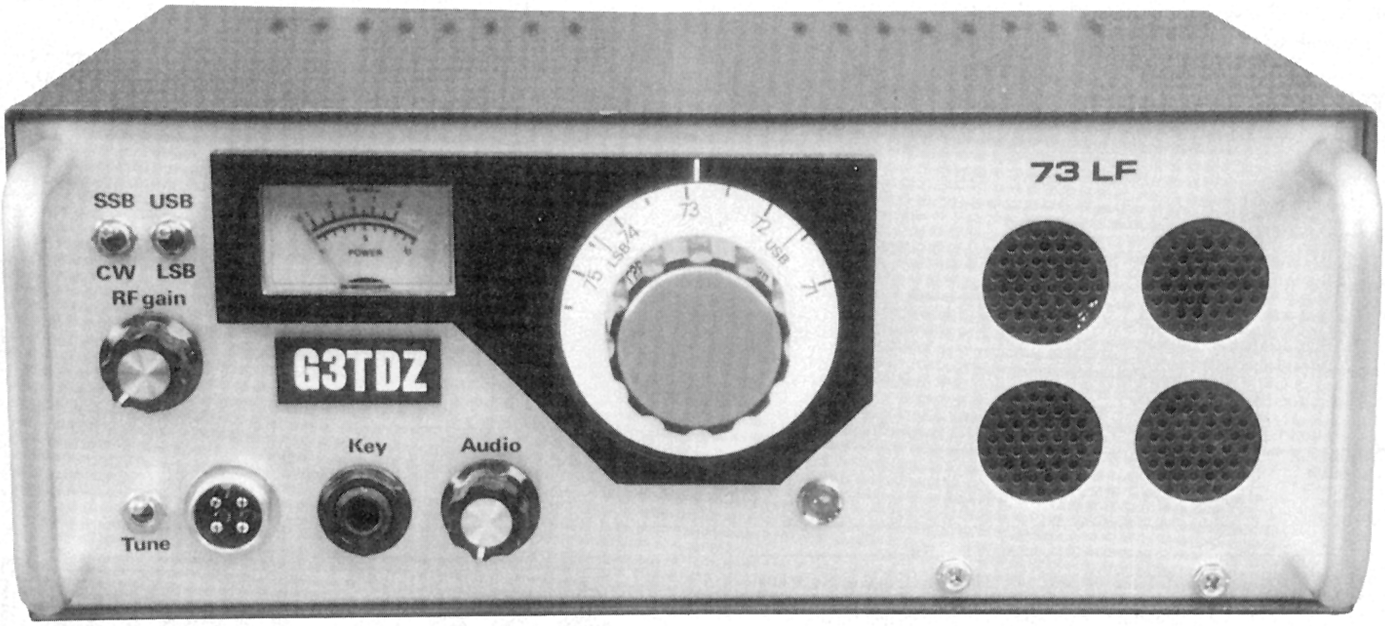
The Phasing Transceiver on 73kHz

*Part one of a two part article by John R Hey, G3TDZ**



THE PHASING TRANSCEIVER which was described in *RadCom* in July and August 1993 still forms the core of my main amateur station. As this has been a success, when the new 73kHz band came along, there seemed little point in developing a new circuit, especially as the printed boards are still available off the shelf.

At such a low frequency, there seems little point in superhet technique; direct conversion on both receive and transmit would seem the obvious path to explore. Here a small admission seems proper: almost two years ago, a pair of LF SSB radios were built for caving use and have proved themselves. With all the experimentation already done, it was only necessary to build another, this time with a VFO replacing the crystal and the S meter and CW filter reintroduced.

THE RECEIVER

THE CASCODE RF amp and VFO amplifier components are omitted from the receiver board. In their place, a small piggy-back board houses the RF amp which now employs a very low noise HF op-amp OP-37. A single input tuned circuit may be used with any antenna input but when connected via the relay, forms with a series tuned loop antenna, a bottom capacity coupled pair with a working Q of 14.

The quadrature pair of injections to the two mixers comes from a divider on the exciter board. **Fig 1** shows the mounting method and **Fig 2** the modified circuitry.

Readers who missed the original articles and would like a copy of the complete receiver may contact me at the address given on this page.

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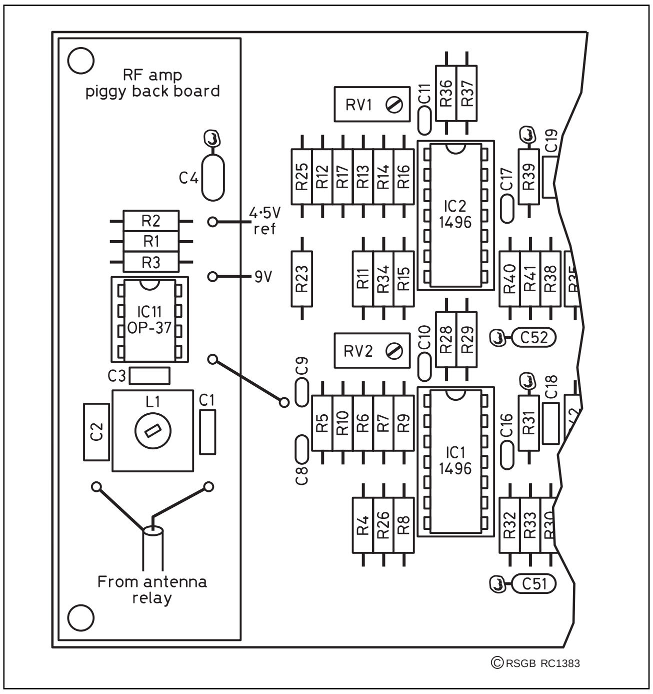

Fig 1: Modified receiver component layout showing the new piggy-back board with the 73kHz components.

THE TRANSMITTER

BECAUSE THERE ARE many more changes, the transmitter is drawn in its entirety and will be shown in the diagram next month. It is very much easier to build a stable VFO at about 4.5MHz and divide down than to try and wind a 390µH coil for 73kHz. The VFO is already very stable; when divided by 64 it is remarkably so. Where desired, crystal control is easy. These components are omitted where the VFO feeds pin 11 of the 4060 divider. The following 4013 divides a further four times and generates the I and Q quadrature signals for both transmitter and receiver. At this low frequency, a DPDT front panel switch enables easy sideband selection.

IC1 performs mic amplifier, low-pass filter, drive for the phase shift networks, and centre rail

reference voltage generator. The phasing networks are buffered by IC2 where audio level equalising is made possible by R25 and RV1. Points A and B should be connected to A and B on the balanced modulators IC3 and IC4 by wires under the board.

The trimpot RV3 equalises conversion gain and RV2 and RV4 are carrier balance. The two modulators are terminated in the tuned circuit L1, C26 which are mounted on the power amp board. Here a car radio audio power chip TDA2003 completes the circuit.

But where is the output tuned circuit and low-pass filter you are asking. As the output resistance is less than an ohm, these would be hard to design - but more on this next month.

THE ANTENNA

IN THE SEPTEMBER 1996 *RadCom* 73LF page, a loop antenna was described. A multi-turn loop will not transmit an E wave but makes an excellent receiving antenna. Unwanted beacons can be nulled out by careful rotation. If a tap four turns up from the earthy end is provided, a long wire such as a topband antenna can be connected and will radiate. A long wire on a kite or balloon, or a barbed wire fence, should radiate better. ♦

. . . to be continued

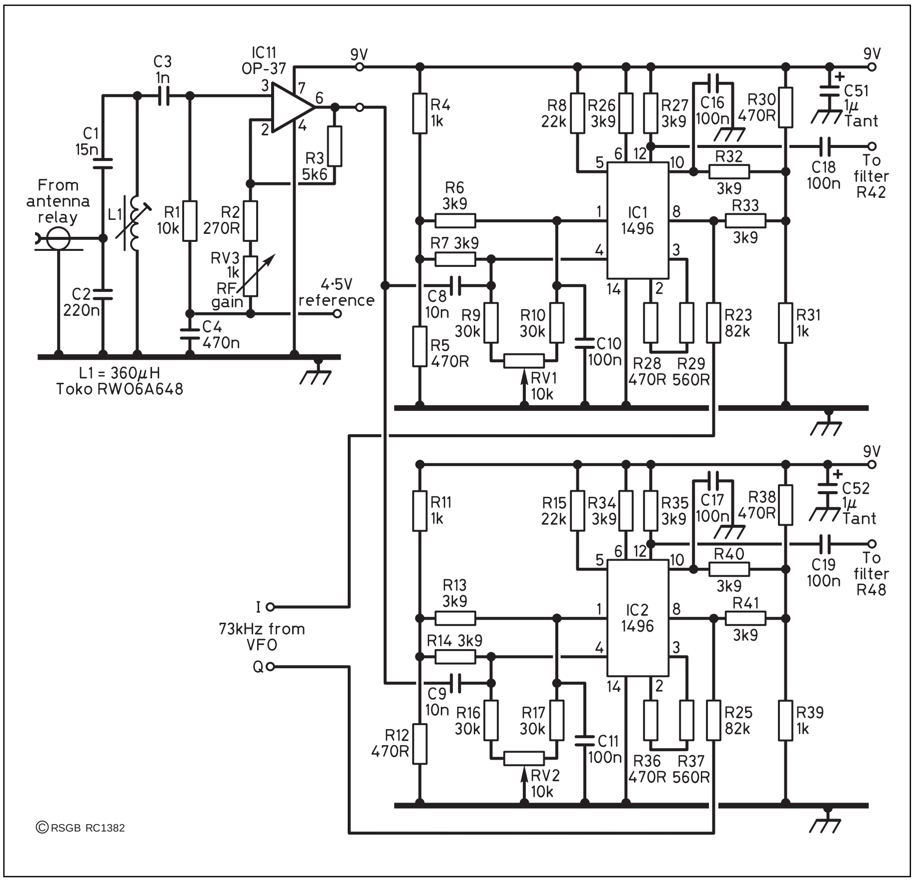

Fig 2: Modified circuitry of the 73kHz section of the receiver.

RADCOM TECHNICAL FEATURE

The Phasing Transceiver on 73kHz

The concluding part by John R Hey, G3TDZ*

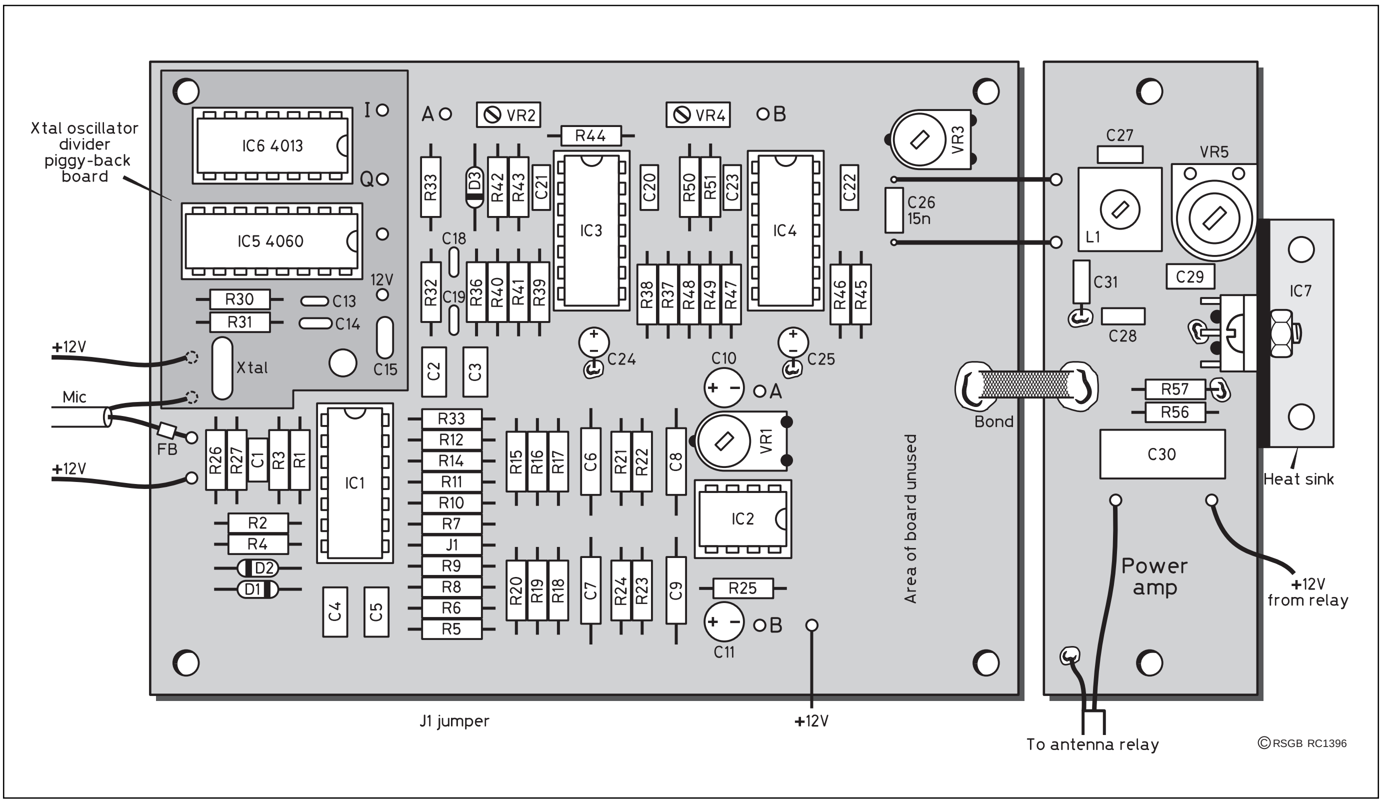

Fig 3: Transmitter board showing the component layout with the crystal oscillator divider piggy-back board in the top left-hand corner.

PORTABLE OPERATION seemed to require attention and to this end, battery power was decided on; a 12V jelly battery worked well. Because of this, the regulators in the receiver and VFO were lowered to 9V. Without these, chaos breaks loose.

As sideband switching now takes place at the oscillator drive, in the receiver, the original sideband switch is not needed; the USB pin should be connected to the sideband switch pin by a hidden wire under the board.

On the exciter where the VFO amplifier and RF phasing network used to be, there is just room for the divider piggy-back board to be mounted, see **Fig 3**. The output transformer and converter are not fitted and their space left blank. As mentioned in part one, the tuned circuit is now fitted on the power amp board. Here a small piece of thick aluminium bolted to the chassis forms a heat sink for the PA stage TDA2003.

A four-pole relay energised from the PTT changes over the antenna, earths the receiver on transmit, mutes the receiver audio on transmit, and powers up the PA. An LED indicates the transmit condition.

A mechanical dial with a 5:1 or even 3:1 slow drive is adequate. Coverage is from 71kHz to 75kHz with about 500Hz overscan.

Use of an op-amp for an RF stage where gain can so easily be specified enables a pot in the feedback return to adjust RF gain.

SETTING UP

IF A COUNTER is available, adjust the VFO coil core (**Fig 4**) so that at tuner mid travel, a reading of 73kHz results at either I or Q terminals or at pin 4 of the 4060. Place a 'scope probe on pin 12 of IC1 and adjust RV1 for minimum signal. Similarly with probe on pin 12 of IC2, adjust RV2 for minimum signal.

Into the antenna socket inject a 73kHz low level signal and tune in to hear a note. Use the lowest level consistent with a clear tone. Tune L1 for maximum. Selecting the other sideband, the tone should all but vanish, but will reappear the other side of zero beat. Advance the RF gain and back off the input. Somewhere just before maximum gain the point of best S/N ratio is achieved. Peak L1 for maximum.

Slowly increase the injection to a point where further increase does not produce a corresponding increase in audio. Adjust the S meter pot for a reading of S9. This completes the receiver alignment.

Transmitter alignment is no more difficult. Connect a 'scope probe to the top of RV5. Adjust L1 for maximum signal. Adjust RV2 for minimum signal; do the same for RV4. Repeat these last two operations, raising 'scope sensitivity till just a line remains. If a two tone generator is not to hand, a single tone audio generator should be fed into the mic input. A sine wave at 73kHz should result at RV5 top, if at this stage a bit raggy. Adjust both RV3 and RV1 till the sine wave becomes clean. With a two-tone generator, these operations are adjusted for the purest waveform.

Connect an antenna and microphone. Connect the 'scope, with Y amp set to its least sensitive, to the junction of L and C on the antenna loop. Speaking into the mic at normal

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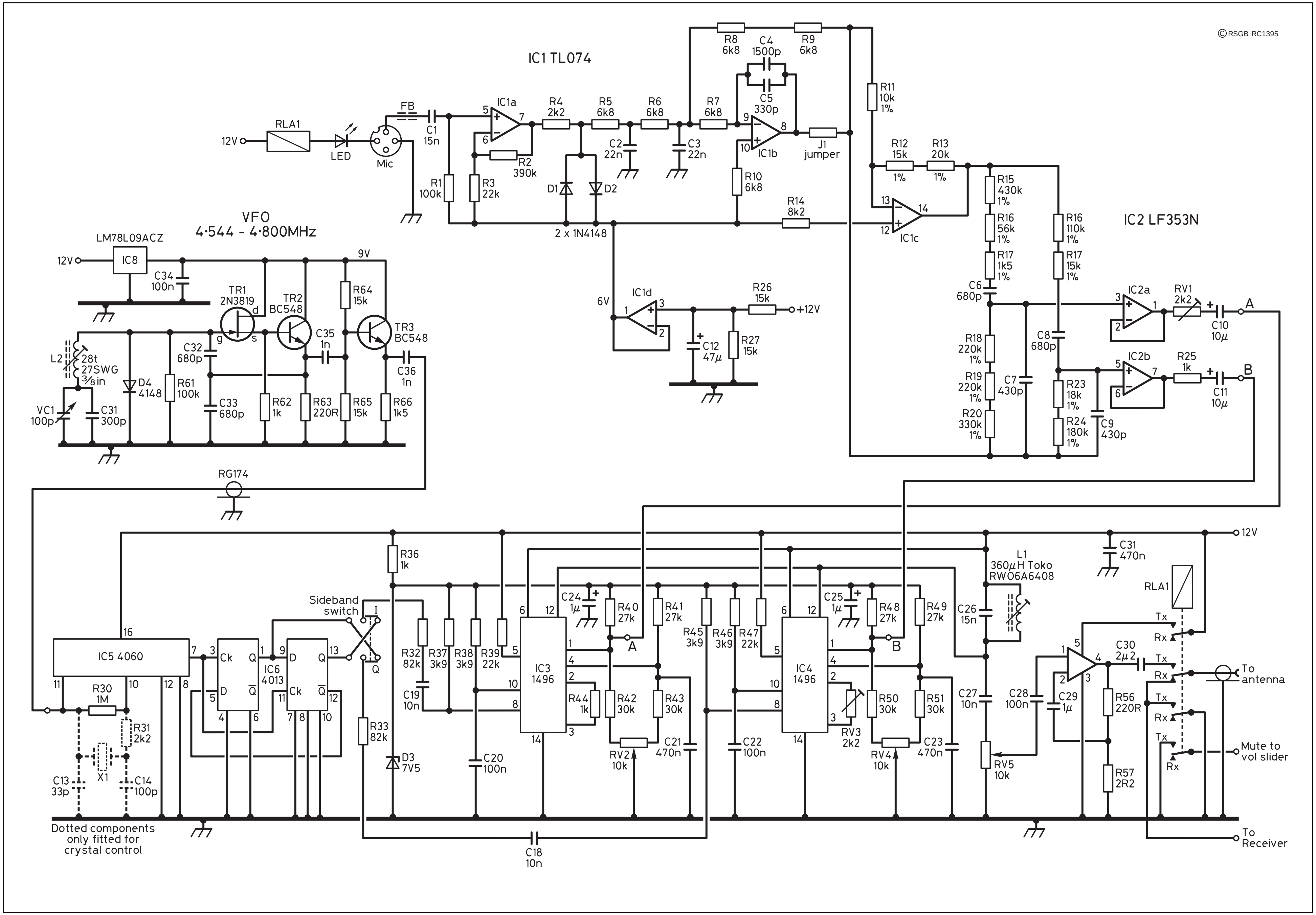

Fig 4: Circuit diagram of the transmitter.

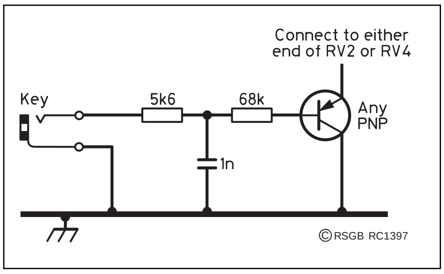

Fig 5: The 73KHz phasing transceiver can operate on CW using this keying method.

level, increase RV5 till the typical SSB waveform is seen to just begin flat topping. The very high Q of the antenna will produce voltages in excess of 240V AC and clean up any roughness in the waveform. An unloaded Q of 81 was measured on the prototype antenna and when connected to the transmitter, a Q of 60 was found. This should reduce the audio bandwidth, but in practice it sounds very good indeed.

OPERATION

MOST OPERATORS WILL be looking towards CW on this band. A simple keying method is to unbalance one of the modulators by turning on a PNP transistor with key down **(Fig 5)**.It is usually easier to send good Morse if you can hear the tone. A better method therefore might be to construct a Morse oscillator and feed this into the microphone socket.

SSB AND CAVING

THE CIRCUIT DESCRIBED has been used as a cave radio [see page 56 - *Ed*]. Crystal control is used in place of the VFO, the S meter circuit may be omitted, and the CW filter disabled by omitting C36 and C37. The CW/SSB switch is permanently wired to SSB under the board. A crystal must be chosen to coincide with one band edge, having chosen your sideband.

The cave radio was constructed in 18 gauge tin plated steel where chassis members were bolted and sweated together. With a waterproof steel case, a mylar speaker, rubber dollies fitted to the switches and the sockets sealed, a reasonably cave-proof set resulted, but just for extra strength was carried in an ammunition case. A chassis drawing is available from the author.

The antenna loop used for underground has Terry clips to hold the wires to the wooden supports for easy dismantling and reassembly. With a multi-turn loop, at the expense of the E wave, the magnetic field is enhanced. One may considered the two loops as primary and secondary of a transformer separated by a few hundred feet of limestone. The signal strength falls off according to an inverse cube law, that is it loses 18dB every time the distance is doubled. A maximum range of 650ft is in theory possible, but about 400ft can be relied upon.

For the amateur looking for DX, the small PA can drive a much larger beast. For ultra slow narrow band Morse or data modes, it is possible to insert a sharp filter at the CW/SSB switch terminals. Much is yet to be written on these finer methods. Meanwhile, the phasing rig makes an easy to get going box of tricks with a proven track record speleologically. ♦

COMPONENTS

Parts list for Modified Receiver Section (Fig 2)

Resistors:	
R1	10k
R2	270
R3	5k6
R4, 11, 31, 39	1k
R5, 12, 28, 30, 36, 38	470
R6, R7, 13, 14, 32, 33, 40, 41	2k2
R8, 15	22k
R9, 10, 16, 17	30k
R26, 27, 34, 35	3k9
R29, 37	560
RV1, RV2	10k 3/8 in Multiturn trimpot
RV3 (Piggy-back board)	1k trimpot or front mounting control (long spindle)
Capacitors:	
C1	15n polyester
C2	220n polyester
C3, C8, C9	1n ceramic plate
C4	470n monolithic (multilayer)
C10, 11, 16, 17	100n monolithic (multilayer)
C18, 19	22n polyester
C51, 52	1µ Tant.
Semiconductors:	
IC1, IC2	MC1496
Other items:	
See original article for full receiver component list.	

Parts list for Transmitter Section (Fig 4)

Resistors:		
R1, R61	100k	
R2	390k	
R3, 39, 47	22k	
R4, 31	2k2	
R5, 6, 7, 8, 9 10	6k8	
R11	10k	1%
R12, 22	15k	1%
R13	20k	1%
R14	8k2	
R15	430k	1%
R16	56k	1%
R17	1k5	1%
R18, 19	220k	1%
R20	330k	1%
R21	110k	1%
R23	18k	1%
R24	180k	1%
R25, 36, 44, 62	1k	
R26, 27, 64, 65	15k	
R30	1M	

Resistors:	
R32, 33	82k
R37, 38, 45, 46	3k9
R40, 41, 48, 49	27k
R42, 43, 50, 51	30k
R56, 63	220
R57	2R2
R66	1k5
RV1, RV3	2k2 cermet horiz. trimpot
RV2, RV4	10k 3/8 in multiturn trimpot
R5	10k cermet horiz. trimpot
Capacitors:	
C1, 26	15n polyester
C2, C3	22n polyester
C4	1500p polypropylene (green Wima)
C5	330p polypropylene (green Wima)
C6, C8, 32, 33	680p plystyrene
C7, C9	430p polystyrene
C10, 11	10µ 16V tant.
C12	47µ 16V radial electrolytic
C13 and C14	only fitted for crystal control.
C15, 20, 22	100n monolithic (multilayer)
C18, 19	10n ceramic disc
C21, 23	470n monolithic
C24, 25	1µ tant
C27	10n polyester
C28, 34	100n polyester
C29	1µ polyester
C30	2µ2 400V polyester
C31	300p polystyrene
C35, 36	1n ceramic plate
Semiconductors:	
IC1	TL074
IC2	LF353N, AD712, 4558 etc.
IC3, IC4	MC1496
IC5	CD4060BCN
IC6	CD4013BCN
IC7	TDA2003V
IC8	LM78L09ACZ
Tr1	2N3819
Tr2, Tr3	BZX79C7V5
Other items:	
L1	Toko RW06A6408 (Cirkit, Bonex)
L2	3/8" Aladdin former 28t, 27SWG
VC1	100p tuner (found at rallies)
RLY1	12V 4 pole changeover 2A
Ant Socket	SO259
Battery	12V 1.2AH Jelly rechargeable.
Sideband Switch	2 pole changeover miniature toggle
Case	Maplin XJ34M

73kHz NEWS

LF Record Increased Again

THE ONE-WAY 73kHz distance record has been dramatically extended from around 22km to 100km. On 12 April, Julian Gannaway, G3YGF/P, located near Rampisham in Dorset, received a 73kHz CW signal from Andy Talbot, G4JNT, near Southampton. Julian received an RST 319 signal from Andy, who was using 100W input to a 6m high 'T' antenna.

It is suggested that all those who can transmit on 73kHz should do so at 11.00am and / or 11.00pm for about 15 minutes any day of the week, but especially Saturday and Sunday. To help experimenters, listeners are urged to send reception reports on all 73kHz-band signals heard by the quickest means possible.

LF in SF

TIMO KIINSI, OH1TH, tells us that from 1 April, Finnish amateurs may use 135.7 - 137.8kHz with 100W power. It was not clear if this was on a special permit basis, or if there were other restrictions.